[NAME OF DOCUMENT] Request of Application for Patent

[FILE NUMBER] E1-98-75

[FILING DATE] December 10, 1998

[ADDRESSEE] Commissioner of the Patent Office

[INTERNATIONAL PATENT CLASSIFICATION] G02B 9/00

[TITLE OF INVENTION] GUIDE PLATE, SURFACE LIGHT SOURCE DEVICE OF SIDE LIGHT TYPE AND LIQUID CRYSTAL DISPLAY

[NUMBER OF CLAIMS] 8

[INVENTOR]

[Address or Residence] c/o Enplas Corporation of 30-1, Namiki 2-chome, Kawaguchi-shi, Saitama

[Name] Kazumasa OHSUMI

[APPLICANT FOR PATENT]

[Identification Number] 000208765

[Name or Trade Name] Enplas Corporation

[Representative] Makoto YOKOTA

[ATTORNEY]

[Identification Number] 100102185

[Patent Attorney]

[Name or Trade Name] Shigenori TADA

[Telephone Number] 03-5950-1478

[FEES]

[Advance Payment Register Number] 047267

[Amount of Payment] 21,000 yen

[LIST OF FILED DOCUMENTS]

[Title of Document] Specification 1

[Title of Document] Drawings 1

[Title of Document] Abstract 1

[PROOF] Requested

[Document] Specification

[Title of Invention] Light Guide Plate, Surface Light Source Device and Liquid Crystal Display

[Claim]

[Claim 1]

A guide plate comprising an incidence face for incidence of illumination light and an emission function face having a function of emitting said illumination light, characterized in that said emission function face is provided with ridges which are arranged repeatedly from the side of said incidence face as to be inclined at an angle falling within a predetermined angle range with respect to said incidence face.

[Claim 2]

A guide plate as defined in claim 1, characterized in that said angle range is from 5 degrees to 45 degrees.

[Claim 3]

A guide plate as defined in claim 1 or 2, characterized in that said ridges have reversely tapered faces located oppositely to said incidence face.

[Claim 4]

A guide plate as defined in claim 1, 2 or 3, characterized in that said ridges are inclined as to entirely biased oppositely to said incidence face as approaching their top sides.

[Claim 5]

A guide plate as defined in claim 1, characterized in that said emission function face includes a stepwise difference between sides of the incidence face and sides opposite to the incidence face such that thickness of the light guide plate is greater at portions, where side faces of said ridges connect with said emission function face at sides opposite to the incidence face side, than at portions, where side faces of said ridges connect with said emission function face at sides of the incidence face.

[Claim 6]

A surface light source device of side light type characterized by employing a light guide plate as defined in claim 1, 2, 3, 4 or 5.

[Claim 7]

A liquid crystal display characterized in that a liquid crystal display panel is illuminated by a surface light source device of side light type as defined in claim 6.

[Claim 8]

A liquid crystal display as defined in claim 7, characterized in that said emission face is arranged on the side of said liquid crystal display panel.

[Detailed Description of Invention]

[0001]

[Field of Invention]

The present invention relates to a light guide plate, surface light source device of side light type and liquid crystal display, being applied, for example, to a liquid crystal display employing a reflection-type liquid crystal display panel. The present invention enables a display screen to shows a sufficient brightness under small-size inconspicuous ridges by means of a plurality of ridges inclined to an incidence face on an emission function face.

[0002]

[Prior Art]

Known so-called reflection-type liquid crystal displays utilizes ambient light to illuminate liquid crystal display panel, thereby saving electric energy consumption as compared with so called transmission-type liquid crystal displays.

[0003]

As proposed, such reflection-type liquid crystal displays give clearly visible display screens under shorted ambient light conditions like in night by being supplied with light from specific light sources such as a frontlighting surface light source device of side light type (See Tokkai-Hei 10-142601).

[0004]

The frontlighting surface light source device of side light type 1 has a light guide plate 3 disposed on a display screen side of a reflection-type liquid crystal display panel

2 and a primary light source 4 beside the light guide plate 3. The primary light source 4 includes, for example, a fluorescent lamp 5 surrounded by a reflector 6 having an opening through which illumination light L is incident to an end face (called incidence face, hereafter) 3A of the light guide plate 3.

[0005]

The guide plate 3 is, for example, a transparent flat-plate-like injection-molded member made of acrylic resin (PMMA resin), having a face 13B on the side of the liquid crystal display (called back face, hereafter) and another face 13C (called front face, hereafter) opposite to the back face 13B, wherein illumination light L introduced into the guide plate 3 through the incidence face 3A propagates within the guide plate with repeated reflections at the faces 3B, 3C.

[0006]

The back face 3B of the light guide plate 3 is provided with a plurality (great number) of ridges 3E having a face 3F approximately perpendicular to the back face 13B and a face 3G approximately parallel to the back face 13B, the ridges 3E running in a direction vertical to a plane of the paper. As shown in a partially enlarged illustration A, illumination light L incident to the ridges 3E is bent by the face 3F approximately perpendicular to the back face 3B and emitted toward the liquid crystal display panel 2. It is noted that ridge means a line-like projection. Thus the back face 3B functions as an emission function face to cause illumination light L propagation within the light guide plate 3 to be emitted toward the liquid crystal display panel 2.

[0007]

The surface light source device of side light type 1 allows ambient light to be supplied to the liquid crystal display panel 2 after being transmit through the light guide plate 3 while allowing illumination light L from the primary light source 4, when the primary light source 4 is switched on under short ambient light conditions, to be supplied to the liquid crystal display panel 2.

[0008]

[Problem to be solved by Invention]

Liquid crystal displays employing the above-described surface light source device of

side light type 1 is subject to a problem that the ridges 3E formed on the light guide plate 3 are visible from the side of the front face 3C and it spoils display quality.

[0009]

Although the problem is solved by a method employing small-width ridges 3E enough to be inconspicuous are, such small-width ridges 3E will cause the emission function face to have a reduced function and the display screen to show insufficient brightness.

[0010]

The present invention has been proposed under consideration of the above-described background, aiming to provide a guide plate, surface light source device of side light type employing the light guide plate and liquid crystal display employing the surface light source device of side light type such that a display screen can show a sufficient brightness if small-size ridges enough to be inconspicuous are formed.

[0011]

[Means for Solving the Problem]

In order to solve such a problem, claim 1 invention provides a light guide plate which has an incidence face for incidence of illumination light and an emission function face having a function of emitting the illumination light, the emission function face being provided with ridges arranged repeatedly from the side of the incidence face as to be inclined at an angle falling within a predetermined angle range with respect to the incidence face.

[0012]

With claim 1 structure, the ridges function as if they have width greater than actual width because of being inclined with respect to the incidence face, causing the illumination light incident thereto to be emitted. This enables the ridges to be small and inconspicuous without spoiling functions of the emission function face, with the result the display screen shows a sufficient brightness.

[0013]

According to claim 2 invention, in the guide plate as defined in claim 1, the angle range is from 5 degrees to 45 degrees.

[0014]

With claim 2 structure, the ridges inclined at from 5 degrees to 45 degrees with respect to the incidence face can perform a practically sufficient function as if they have width greater than actual width.

[0015]

According to claim 3 invention, the structure as defined in claim 1 or 2 has ridges reversely tapered faces located oppositely to the incidence face.

[0016]

With claim 3 structure, the reversely tapered faces located oppositely to the incidence face reflect light propagating within the light guide plate and cause the light to be emitted from the function face at small emission angles, with the result the liquid crystal display panel is supplied with illumination light with directivity suitable for characteristics of the liquid crystal display panel.

[0017]

According to claim 4 invention, the guide plate as defined in claim 1, 2 or 3 has ridges which are inclined as to entirely biased oppositely to the incidence face as approaching their top sides.

[0018]

With claim 4 structure, since the ridges are inclined as to entirely biased oppositely to the incidence face as approaching their top sides, molding process such injection molding using a mold can be performed under good characteristics of mold separation.

[0019]

According to claim 5 invention, the structure as defined in claim 1 has an emission function face that includes a stepwise difference between sides of the incidence face and sides opposite to the incidence face such that thickness of the light guide plate is greater at portions, where side faces of the ridges connect with the emission function face at sides opposite to the incidence face side, than at portions, where side faces of the ridges connect with the emission function face at sides of the incidence face.

[0020]

With claim 5 structure, the stepwise difference between sides of the incidence face

and sides opposite to the incidence face causes only light incident to the sides opposite to the incidence face at large incidence angles selectively to impinge to the faces opposite to the incidence face, and accordingly enabling the light guide plate to provide an emission at small emission angles.

[0021]

Claim 6 invention provides a surface light source device of side light type employing a light guide plate as defined in claim 1, 2, 3, 4 or 5.

[0022]

With claim 6 structure, if small and inconspicuous ridges are formed, an emission with a sufficient brightness is provided.

[0023]

According to claim 7 invention, a liquid crystal display panel is illuminated by a surface light source device of side light type as defined in claim 6.

[0024]

With claim 7 structure, if small and inconspicuous ridges are formed, a display screen shows a sufficient brightness.

[0025]

According to claim 8 invention, the emission function face in the structure as claimed in claim 7 is arranged on the side of the liquid crystal display panel.

[0026]

With claim 8 structure, since the emission function face is arranged on the side of the liquid crystal display panel, the other face opposite to the emission function face may be a flat face to prevent characteristics from getting inferior.

[0027]

[Embodiments]

Embodiments of the present invention is described below in details with referring to drawings as required. In the drawings, parts are exaggerated for the sake of easy understanding.

[0028]

(1) First Embodiment

(1-1) Structure of the First Embodiment

Fig.1 is a perspective view from the bottom side of a liquid crystal display of a first embodiment in accordance with the present invention and Fig.2 is a cross section view along lien B-B in Fig.1. This liquid crystal display 10 comprises a liquid crystal display panel 11 of reflection type and a surface light source device of side light type 12 disposed on the front side of the liquid crystal display panel.

[0029]

The liquid crystal display panel 11 includes a reflection plate 11A, glass substrate 11B, liquid crystal layer 11C and glass substrate 11D, which are laminated in order from the bottom side, providing a desired image by driving transparent matrix-like electrodes formed on the glass substrates 11B and 11D by means of a driving circuit not shown.

[0030]

The surface light source device 12 comprises a guide plate 13 disposed in front of the liquid crystal display panel 11 and a primary light source 14 disposed beside an end face (illumination light incidence face) of the light guide plate 13. The primary light source 14 is composed of, for example, a fluorescent lamp 15 and a reflector 16 surrounding the lamp, the reflector 16 having an opening through which illumination light L is incident to an incidence face 132A that is an end face of the light guide plate.

[0031]

The guide plate 13 is, for example, a transparent flat-plate-like injection-molded member made of acrylic resin (PMMA resin), having a back face 13B and front face 13C, wherein illumination light L introduced through the incidence face 13A propagates within the guide plate with repeated reflections at the faces 13B, 13C. As shown in a partially enlarged illustration C in Fig.1, the back face (illumination light emission function face) of the light guide plate 13 is provided with ridges 13E arranged repeatedly.

[0032]

The ridges 13E are arranged repeatedly from the side of the incidence face 13A, being inclined at angle α with respect to the incidence face 13A. This ENABLES the ridges 13E to function as if they have width greater than actual width for the illumination light L incident thereto from the side of the incidence face 13A, causing the illumination

light L to be emitted, if the ridges are small, without spoiling the function of the emission function face. To cause the ridges 13E to function for emitting light as if they have a width greater than an actual width, angle α made by the ridges 13E and the incidence face 13A falls preferably in a range from 5 degrees to 45 degrees, in particular, from 15 degrees to 30 degrees.

[0033]

The ridges 13E are formed as to have approximately the same shape cross sections along a plane parallel to the front face 13C, the cross sections getting smaller from their feet toward their tops, and are inclined as to be biased as a whole, from their feet toward their tops, to the side opposite to the incidence face 13A (called " light guide plate distal end side ").

This causes the ridges 13E to have a shape having a trapezoid-like cross section with inversely tapered light guide plate distal end side's side faces 13B, as shown in an enlarged cross section view D (in Fig.2) of the ridges 13F along a plane vertical to the incidence face 13a and the front face 13C.

[0034]

As shown in an enlarged illustration E of directivity of illumination light L, the illumination light L propagating within the light guide plate 13 with being reflected at the front face 13C an d back face 13B is incident to the back face 13B at angles greater than the critical angle θ 1. At portions formed of ridges 13E, the illumination light L enters into the ridge 13E from a foot portion, showing directivity distributed at angles greater than the critical angle θ and smaller than 90 degrees with respect to a normal of the back face 13B. Please note that the critical angle θ 1 of acrylic resin of which the light guide plate 13 is made is 42.3 degrees.

[0035]

As described with referring to Fig.12, if ridges are formed by faces vertical to the back face 13B and parallel to the back face 13B, illumination light with so-called laid-down directivity (arrow M in Fig.12) is emitted toward the liquid crystal display panel 11, failing to be supplied to the liquid crystal display panel 11 with a suitable directivity (emission distributing within 30 degrees around a normal of the liquid crystal

display 11).

[0036]

Therefore the ridges 13E in this embodiment have a sharp angle a which is made by the light guide plate distal end side's side face 13EB and back face 13B as shown in the cross section illustration, and the light guide plate distal end side's side face 13EB total-reflects the illumination light L to cause the illumination light L to be emitted toward the liquid crystal display panel 11 at small incidence angles.

Thus the ridges 13E cause the illumination light L to be emitted with directivity suitable for displaying of the liquid crystal display panel 11, as shown in illustration F. It is noted that inclination of the critical angle with respect to the liquid crystal display panel 11 is shown by dotted line in characteristic curves P.

[0037]

It is noted that directivity of such incident light to the back face 13B changes variously depending on thickness of the light guide plate 13, relations between the incidence face 13A and the primary light source 14 and other factors. Thus angle a of the ridges 13E is set, depending on these conditions, as to fall within a range 45 degrees <a< 90 degrees, more preferably 60 degrees <a< 80 degrees, enabling illumination light incident to the light guide plate distal end side's side face 13B to be totally-reflected and to provide an emission from the back face of the light guide plate 13 incident to the liquid crystal display panel 11 at a small incident angle.

[0038]

Angle b of the ridges 13E made by the incidence face side face 13EB on the opposite side and the back face 13B is set so that the illumination light L incident to the light guide plate distal end side's side face 13EB with such directivity is not shielded and the light guide plate distal end side's side face 13EB is inversely tapered for the sake of practically easy mold separation characteristics.

Concretely saying, this angle b is set, within a range from (critical angle θ 1 + 90 degrees) to (180 degrees − angle a), so that practically easy mold separation characteristics are obtained.

[0039]

Height h of the ridges 13E from the back face 13B to the tops of the ridges is set at 20 [μ m] so that practically easy mold separation characteristics are obtained under the above-mentioned angles a, b and a certain width W. It is noted that practically sufficient characteristics are obtained if height h falls within a rage 50 % to 100 % with respect to width W1. It is further noted that width W is width of a foot portion which is formed as a cross section along a plane perpendicular to the incidence face 13A and the front face 13C.

[0040]

The ridges 13E as above promote emission of illumination light L propagating within the light guide plate 13 to the side of the liquid crystal display panel 11, with the result quantity of the illumination light L propagating within the light guide plate 13 get smaller from the incidence face 13A to the light guide plate distal end side.

[0041]

Under consideration of this, intervals of the ridges 13E on the back face 13B get smaller gradually from the incidence face 13A to the light guide plate distal end side, thereby providing a uniformalized light quantity distribution of the emission toward the liquid crystal display panel 11.

[0042]

(1-2) Operation of the First Embodiment

In the above construction, the liquid crystal display 10 (Figs.1 and 2), if ambient light is incident, the ambient light transmits through the light guide plate 13 of the surface light source device of side light type 12 and further through the glass substrate 11D, liquid crystal layer 11C and the glass substrate 11B in order of the liquid crystal display panel 11, being reflected by the reflection plate 11A.

The ambient light reflected by the reflection plate 11A is further transmits through the glass substrate 11B, liquid crystal layer 11C and the glass substrate 11D and further through the light guide plate 13 of the surface light source device of side light type 12, being emitted.

[0043]

Thus emitted ambient light, which is emitted from the liquid crystal display panel 11

after being incident thereto, is polarized during transmitting the liquid crystal layer 11C corresponding to an image to be displayed, thereby enabling an image on the liquid crystal display panel 11 to be visible from the side of the front face of the light guide plate 13.

Thus, if the ambient light is sufficient, the liquid crystal display 10 provides a visible display image under usage of only ambient light.

[0044]

To the contrary, if the ambient light is insufficient, the fluorescent lamp 15 of the surface light source device of side light type 12 is switched on and illumination light L emitted from the fluorescent lamp 15 is directly, or after being reflect3ed by the reflector 16, introduced into the light guide plate 13 through the incidence face 13A of the light guide plate 13.

[0045]

The illumination light L introduced into the light guide plate 13 propagates within the light guide plate 13 while the front face 13C and back face 13B of the light guide plate 13 reflect repeatedly components incident to them at angles greater than the critical angle.

[0046]

Some of such illumination light L propagating within the light guide plate 13 enters into the ridges 13E formed on the back face 13B, being incident to the light guide plate distal end side's side faces 13EB of the ridges 13E.

Such incident illumination light L is, although the incident angle to the back face 13B is laid down and greater than the critical angle, reflected by the light guide plate distal end side's side faces 13EB in a direction of a normal of the back face 13B and thus reflected illumination light L is emitted through top flat faces of the ridges 13E toward the liquid crystal display panel 11 because the ridges are inclined to the distal end side of the light guide plate 13 as to make the light guide plate distal end side's side faces 13EB reversely tapered.

[0047]

Thus the illumination light L emitted toward the liquid crystal display panel 11 has an emission directivity that is near to a direction of a normal of the liquid crystal display panel 11 as compared with prior arts and suitable for characteristics of the liquid crystal display panel11.

[0048]

Such illumination light L reflected by the light guide plate distal end side's side faces 13EB of the ridges 13E can be obtained by being efficiently incident to the approximately whole area of the light guide plate distal end side's side faces 13EB because the incidence face side faces 13EA oppositely located are inclined at angle b as to not shield the illumination light L.

[0049]

The incidence face side faces 13EA of the ridges 13E have angle b with respect to the back face 13B as to not shield the illumination light L and the angle b is set as to have sufficient mold separation characteristics, keeping molding property of the light guide plate 13.

[0050]

Since the liquid crystal display 10 can be illuminated by ambient light and illumination light L supplied by the surface light source device of side light type 12 with directivity suitable for characteristics of the liquid crystal display panel 11, the liquid crystal display panel 11 can give a sufficient brightness to the displayed image even if the liquid crystal display panel 11 is supplied with smaller quantity of illumination light L as compared with prior arts. And this causes the liquid crystal display 10 to save electric power consumption.

[0051]

The ridges 13E cause the illumination light L propagating within the light guide plate 13 to be emitted to the liquid crystal display panel 11, with the result quantity of the illumination light L propagating within the light guide plate 13 get smaller toward the distal end side of the light guide plate 13.

Under consideration of this, intervals of the ridges 13E get smaller gradually from

the incidence face 13A to the light guide plate distal end side, thereby compensating reduced quantity of inner-propagating illumination light L by means of function of promoting emission of the illumination light L enforced by increased number of arranged ridges E, with the result the liquid crystal display 11 is supplied with illumination light normalized over the whole back face 13B. This prevents the display screen from having unevenness in brightness.

[0052]

Further, the present embodiment can avoid the ridges 13E from looking white-clouded under ambient light, thereby preventing image quality and contrast from being reduced, because the top side portions of the ridges 13E are inclined to the light guide plate distal end side.

[0053]

If the ridges 3E as shown in previous referred Fig.12 are formed on the light guide plate 3, ambient light LR incident to the side face 3F at angles greater than the critical angle is reflected at the side face 3F, bottom face 3G and side face 3F in order and then emitted from the front face of the light guide plate 3, as illustrated in Fig.3.

In such a case, the ridges 3E look white-clouded as viewed from the side of the front face of the light guide plate 3, leading to a remarkable reduction in image quality. It is noted that drawing-taper general in injection molding is applied to the ridges 3F shown in Fig.3.

[0054]

To the contrary, in the case of the present embodiment, ambient light LR entering on a path similar to that shown in Fig.3 can be emitted toward the liquid crystal display panel 11 from the back face of the light guide plate 13 like ambient light LR' incident to other than the ridges 13E, by means of reflections at the light guide plate distal end side's side faces (That is, ambient light LR does not return to the side of the front face 13C as the case shown in Fig.3 does). This avoids the ridges 13E from looking white-clouded.

[0055]

With the back face 13B functioning as an emission function face as such due to the

ridges 13E, if the ridges 13E small enough to be inconspicuous were arranged in parallel with the incidence face 13A like prior arts, the function of the emission function face would be reduced.

[0056]

On the other hand, since the present embodiment arranges the ridges 13E as to be inclined with respect to the incidence face 13A as shown in Fig.5 in contrast with prior arts (Fig.5(A)), width W of foot portions as cross sections along a plane perpendicular to the incidence face 13A and the front face 13C is greater than width WD of foot portions as cross sections along a plane perpendicular to the light guide plate distal end side's side faces 13EB.

[0057]

Under this situation, the propagation direction of illumination light L propagating within the light guide plate 13 is directed to a normal of the incidence face 13A corresponding to wider side width W. Thus the present embodiment causes the ridges 13E inclined with respect to the incidence face 13A to function for providing illumination light emission as if they are wider than actual, with the result the ridges small enough to look inconspicuous can provide emission without spoiling the function of the emission function ace.

Even if the ridges may be inclined inversely as compared with the present embodiment as shown in Fig.5(C), they function as if they are wider than actual for providing emission.

[0058]

Such inclined arrangements will reduce interference fringes which might be caused depending on the relation between repetition period of pixel of the liquid crystal display panel 11 and repetition period of the ridges 13E.

[0059]

In practical uses, angle α must be not less than 5 degrees in order that the inclined ridges practically function as if they are wider than actual, and angle α not less than 15 degrees show striking effects.

However, if extremely large angles are set, although width W1 along a plane vertical

to the incidence face 13A and the front face 13C become great, illumination light propagating toward the wedge distal end is reflected by the light guide plate distal end side faces 13EB and emitted toward the liquid crystal display panel 11 in side directions of the light guide plate 13, with the result incident angles of the illumination light to the liquid crystal display panel 11 can not be small.

This tendency is considerable if angle α is not less than 30 degrees, and angle α not less than 45 degrees causes the ridges arranged repeatedly from the incidence face 13A to lose their practical technical significance.

[0060]

Thus inclination angle α ranging from 5 degrees to 45 degrees allows the ridges small enough to look inconspicuous to provide sufficiently bright display screen, and a preferable range from 15 degrees to 30 degrees provides striking effects.

[0061]

（１－３）第１の実掩の形態の効呆

(Effect of the First Embodiment)

According to the above−described construction, the ridges 13E providing the light guide plate 13 with the emission function face are inclined with respect to the incidence face 13A enables the ridges 13F to work for causing the illumination light to be emitted as if they have a width than actual, with the result the ridges small enough to be inconspicuous enable the display screen to show a sufficient brightness.

[0062]

Under the range of angle made the ridges 13E and incidence face 13E from 5 degrees to 45 degrees, the ridges 13E work as if they have a width than actual and, if small enough to be inconspicuous, enable the display screen to show a sufficient brightness.

[0063]

Further, since the ridges are formed so that the faces 13Eb located oppositely to the side of the incidence face 13A are inversely tapered, these light guide plate distal end side's side faces 13EB reflect illumination light L propagation within the light guide plate 13 so that the illumination light L is supplied at small incidence angeles with respect a

normal of the liquid crystal display panel 11. This enables supply of the illumination light L to have a directivity suitable for the liquid crystal display panel 11.

[0064]

Further, since the ridges are inclined as a whole from foot portions to the top portions oppositely to the incidence face 13A, a sufficient mold separation property is kept during molding processes under a condition such that the light guide plate distal end side's side faces 13EB are tapered inversely, with the result that light guide plates are manufactured efficiently.

[0065]

(2) Second Embodiment

Fig.6 is an exploded perspective view of a liquid crystal display of a second embodiment in accordance with the present invention and Fig.7 is a cross section view of the display shown in Fig.6 along line G−G. The liquid crystal display 20 of this embodiment employs a surface light source device of side light type 22 instead of the surface light source device of side light type 12.

It is noted that common constructions employed both in the liquid crystal display 20 and liquid crystal display 10 are denoted by the same references and repeated description is omitted.

[0066]

The surface light source device of side light type 22 is the same as the above−described surface light source device of side light type 12 shown in Fig.1 except that a light guide plate 23 is employed instead of the light guide plate 13.

[0067]

The guide plate 23 is, for example, a transparent flat−plate−like injection−molded member made of acrylic resin (PMMA resin), having a back face 23B and front face 23C, wherein illumination light L introduced through the incidence face 23A propagates within the guide plate with repeated reflections at the faces 23B, 23C.

[0068]

The light guide plate 23 is provided with ridges 23E arranged repeatedly and obliquely with respect to the incidence face 23A at angle α in the same manner as in

the case of the light guide plate 13. This

This enables the ridges 23E in the surface light source device of side light type 22 to work for emission of illumination light L as if they are wider than actual, with the result the ridges small enough to look inconspicuous can provide emission without spoiling function of an emission function ace.

[0069]

Each ridge 23E is formed by a pair of side faces 23EA, 23B, which are approximately parallel to each other, and a bottom face 23 F which are approximately parallel to a face 23C connecting the top portions of the side faces 23EA, 23B, with the result that each ridge has a generally rectangular cross section.

[0070]

The ridges 23E are arranged as to have intervals getting smaller according to an increasing dIstance from the incidence face 23A, thereby enabling the light guide plate 23 to compensate shorted inner-propagation illumination light L on the distal end side for causing the liquid crystal display panel 11 to be supplied with illumination light with a uniform brightness distribution.

[0071]

Further, each ridge 23E has, at the side face 23FB, a height that is smaller than a height by a certain length at the side face 23EA opposite to the side face 23EB on the side of the incidence face 23A.

With this structure, the light guide plate 23 has stepwise differences between sides of the incidence face 23A and sides opposite to the incidence face 23A of the ridges so that plate thickness is greater at portions, where side faces 23B of the ridges 23E connect with the BACK FACES 23B at sides opposite to the incidence face side, than at portions, where side faces 23EA of the ridges 23E connect with the back face 23B at sides of the incidence face.

[0072]

The back face 23B of the light guide plate 23 has inclinations between the ridges 23E corresponding to the differences between the side faces 23EA and 23EB, wherein the inclinations get greater according to an increasing distance from the incidence face

23A due to the intervals between the ridges 23E getting smaller according to an increasing distance from the incidence face 23A.

[0073]

This causes the light guide plate 23 to have limited incidence angles of illumination light L incident to the side faces 23B of the light guide plate distal end side, with the result that illumination light L is emitted with directivity suitable for the liquid crystal display panel 11.

[0074]

That is, as shown in Fig.8, under a condition such that a side face 3F is approximately vertical to the back face 3B and the critical angle is θ , if the differences are absent, without stepwise differences, illumination light L is incident to the side face 3F on the distal end side of the light guide plate 3 at an incident angle ranging from 0 degree to θ .

Such illumination light L incident to the side face 3F at incident angles not greater than the critical angle is emitted with being refracted at the side face 3F, with the result that illumination light components L1 having small incident angles are emitted at large angles with respect to a normal of the liquid crystal display panel 11 (namely, with respect to a normal of the back face 3B).

In other words, without stepwise differences, the emitted illumination light L from the light guide plate 3 contain a lot of such light components which are incident to the liquid crystal display panel 11 at large angles with respect to a normal of the liquid crystal display panel 11, unabling the liquid crystal display panel 11 to be supplied with illumination light L with directivity suitable for characteristics of the liquid crystal display panel 11.

[0075]

To the contrary, a stepwise difference formed between a side face 23EA and 23EB as shown in Fig.9 can avoid illumination light components L1, which come at small angles with respect to a normal of the light guide plate distal end side's side face 23B. to be incident to the side face 23EB.

[0076]

This permits only illumination light components L coming at relatively large incident angles with respect to the side face 23B to be selectively incident to the light guide plate distal end side's side face 23EB, with the result that this illumination light L with such large incident angles can be emitted toward the liquid crystal display panel 11 at small incident angles with respect to the liquid crystal display panel 11.

Thus the light guide plate 23 can provide a supply of illumination light L with directivity suitable for characteristics of the liquid crystal display panel 11.

[0077]

It is noted that illumination light L coming to the side faces 23EB at small incident angles is reflected by the inclined back face 23B and accordingly have reduced incident angles to the front face 23C. Thus, when illumination light L propagating within the light guide plate 23 is incident to the side faces again, increased incident angles to the light guide plate distal end side's side face 23EB are realized.

As a result, this light becomes light components that is allowed to impinge to the side faces 23EB of the next adjacent ridges 23E, the light components being emitted toward the liquid crystal display panel at small incident angles with respect to the panel face of the liquid crystal display panel 11.

This enables the light guide plate 23 to utilize inner propagation illumination light without loss if incident light to the ridges 23E is limited by the stepwise differences between the side faces 23EA and 23EB.

[0078]

In such cases where angles of illumination light L at incidence to the side faces 23EB is limited by the stepwise differences between the side faces 23EA and 23EB, an illumination light L approaching the side face 23EB at a small angle $\theta = \tan^{-1}(d/W)$ can avoid to be incident to the side faces 23EB, where d is stepwise difference and W is distance between side faces 23EA and 23EB (I.E. width of ridge).

In this embodiment, stepwise differences d and intervals W are chosen so that angle θ is not less than 5 degrees, providing emission of illumination light L with a practically sufficient directivity.

[0079]

Width W is chosen suitably in a range from 5 μ m to 50 μ m, avoiding the ridges 23E from being visible directly from the front face side.

[0080]

With the above structure, if the ridges 23E, each of which has a rectangular cross section, accompany stepwise differences between ridges 23E with inclined portions, the ridges running as to be inclined with respect to the incidence face 23A bring advantages similar to those of the first embodiment.

[0081]

Further, the inclined portions between ridges 23E provided by the stepwise differences of the ridges 23E enable illumination light approaching the light guide plate distal end side's side face 23EB to be incident to the light guide plate distal end side's side face 23EB and to be emitted at small incident angles with respect to the panel face of the liquid crystal display panel 11.

As a result, the liquid crystal display panel 11 is supplied with illumination light at small incident angles, and accordingly with directivity suitable for characteristics of the liquid crystal display panel.

[0082]

(3) Third Embodiment

Fig.10 is an exploded perspective view of a liquid crystal display of a third embodiment in accordance with the present invention to be compared with Fig.1. The liquid crystal display 30 comprises a surface light source device of side light type 32 instead of the surface light source device of side light type 12, the surface light source device of side light type 32 employing a guide plate 33 instead of the guide plate 13.

[0083]

The guide plate 33 is, for example, a transparent flat-plate-like injection-molded member made of acrylic resin (PMMA resin), having a back face 33B provided with ridges 33E.

The ridges 33E are arranged repeatedly as to be inclined at a certain inclination angle α with respect to the incidence face 33A and to have intervals getting smaller according to an increasing distance from the incidence face 33A.

[0084]

It is further noted that the ridges 33E are shaped as to have rectangular cross sections in a similar way as compared with the prior art ridges 3E described with referring to Fig.12.

[0085]

With the structure as shown in Fig.10, if the ridges 33E are merely shaped as to have rectangular cross sections, the ridges 33E can work as if they have width greater than actual for causing illumination light L to be emitted, with the result the ridges 33E small enough to be inconspicuous can provide a sufficiently bright display screen.

[0086]

(4) Other Embodiments

Although the first embodiment describes that the ridges are shaped as to have cross sections decreasing toward distal ends, this does not limit the scope of the present invention, and the ridges may be alternatively inclined and shaped as to have constant cross sections as required, which provide effects like those in the first embodiment.

[0087]

Further, although the first embodiment describes that an incidence face side's side face of each ridge is also inclined, this does not limit the scope of the present invention, and, if the ridges are formed by processing after molding, the incidence face side's side face can be formed as to be generally vertical to the back face.

[0088]

Further, although the second embodiment describes that the back face includes wholelly inclined intervening portions between ridges, this does not limit the scope of the present invention, and the intervening portions may be partially inclined.

[0089]

Further, although the above embodiments describe that ridges are formed on a back face of a light guide plate to have the back face work as an emission function face, this does not limit the scope of the present invention, and the present invention may be broadly applied to cases where ridges are formed on a front face of a light guide plate to have the front face work as an emission function face.

It is noted that Fig.11 shows a liquid crystal display 40 including a surface light source device of side light type 32 employing a light guide plate 33 having a front face provided with ridges 43E formed by a pair of slopes 43EA, 43EB providing a triangular cross section.

[0090]

Further, although the above embodiments describe that ridges are formed obliquely with respect to an incidence face on a flat-type light guide plate, this does not limit the scope of the present invention, and ridges may be formed obliquely with respect to an incidence face on a light guide plate having a wedge-like cross section, which provide effects like those in the above-described embodiments.

[0091]

Further, although the above embodiments describe that illumination light is incident to one side end face, this does not limit the scope of the present invention, and the present invention may be applied to a surface light source device of side light type in which illumination light is also incident to other side end face(s).

[0092]

Further, although the above embodiments describe that the primary light source is provided by a rod-like fluorescent lamp, this does not limit the scope of the present invention, and the present invention may be broadly applied to cases point-like light sources like LEDs are arranged to provide a primary light source.

[0093]

Further, although the above embodiments describe that light guide plates have flat and smooth front faces (without ridges), this does not limit the scope of the present invention, and an antireflection film by such as coating or non-glearing processing may be applied to a front face.

[0094]

Further, although the above embodiments describe that each light guide plate shown in figures has a front (or back) face generally vertical to an incidence face, this does not limit the scope of the present invention, and the incidence face may be inclined as to make a sharp or dull angle with the front face.

[0095]

Further, although the above embodiments describe that the present invention is applied to surface light source devices of side light type of liquid crystal displays, this does not limit the scope of the present invention, and the present invention may be applied broadly to surface light source device of sides light type for various illumination devices, displays or the like.

[0096]

[Merits of Invention]

As described above, according to the present invention, since ridges providing an emission face function face of a light guide plate are arranged obliquely with respect to an incidence face, if the ridges are formed as to be inconspicuous, the light guide plate can give a display screen sufficiently brightness, and accordingly, the present invention provides a surface light source device of side light type and liquid crystal display employing the light guide plate.

[Brief Description of Drawings]

[Fig.1]

An exploded perspective view of a liquid crystal display of a first embodiment in accordance with the present invention;

[Fig.2]

A cross section view along line B–B in Fig.1;

[Fig.3]

A cross section view illustrating light paths of ambient light in a case where ridges are formed by vertical faces;

[Fig.4]

A cross section view illustrating light paths of ambient light for comparing with Fig.3;

[Fig.5]

Plan views illustrating operations of obliquely extending ridges;

[Fig.6]

An exploded perspective view of a liquid crystal display of a second embodiment in

accordance with the present invention;

[Fig.7]

A cross section view along line G–G shown in Fig.6;

[Fig.8]

A cross section view illustrating light paths of illumination light in a case where ridges accompany no stepwise difference;

[Fig.9]

A cross section view illustrating light paths of illumination light in a case of ridges shown in Fig.7;

[Fig.10]

An exploded perspective view of a liquid crystal display of a third embodiment in accordance with the present invention;

[Fig.11]

A cross section view of a liquid crystal display of another embodiment in accordance with the present invention;

[Fig.12]

A cross section view of a conventional surface light source device of side light type.

[Description of References]

1, 12, 22, 32, 42 surface light source device of side light type

2, 11 liquid crystal display panel

3, 13, 23, 33, 43 light guide plate

3A, 13A, 23A, 33A incidence face

3B, 13B, 23B, 33B back face

3E, 13E, 23E, 33E, 43E ridge

4, 14 primary light source

1O, 20, 30, 40 liquid crystal display

[Document] Abstract

[Object] The present invention relates to a light guide plate, surface light source device of side light type and liquid crystal display, being applied to a liquid crystal display employing a reflection-type liquid crystal display panel, wherein inconspicuous ridges formed on an emission function face and display screen shows a sufficient brightness.

[Solving Means] A plurality of ridges E are arranged on an emission function face 13B as to be inclined with respect to an incidence face 13A.

[Selected Figure] Fig.1

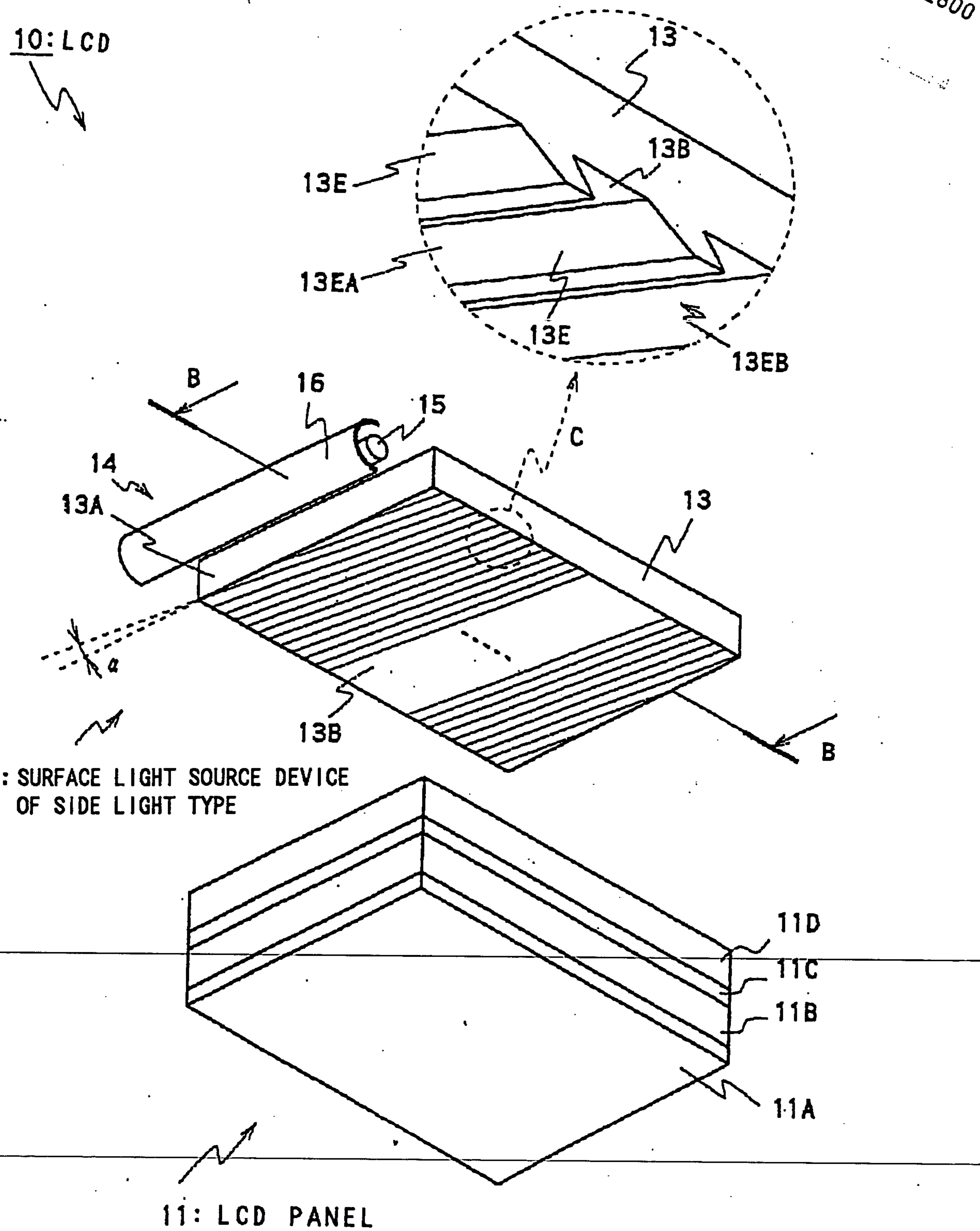
10: LCD
13
13B
13E
13EA
13E
13EB
B
16
15
C
14
13A
13
α
13B
B
12: SURFACE LIGHT SOURCE DEVICE
OF SIDE LIGHT TYPE
11D
11C
11B
11A
11: LCD PANEL

Fig.1

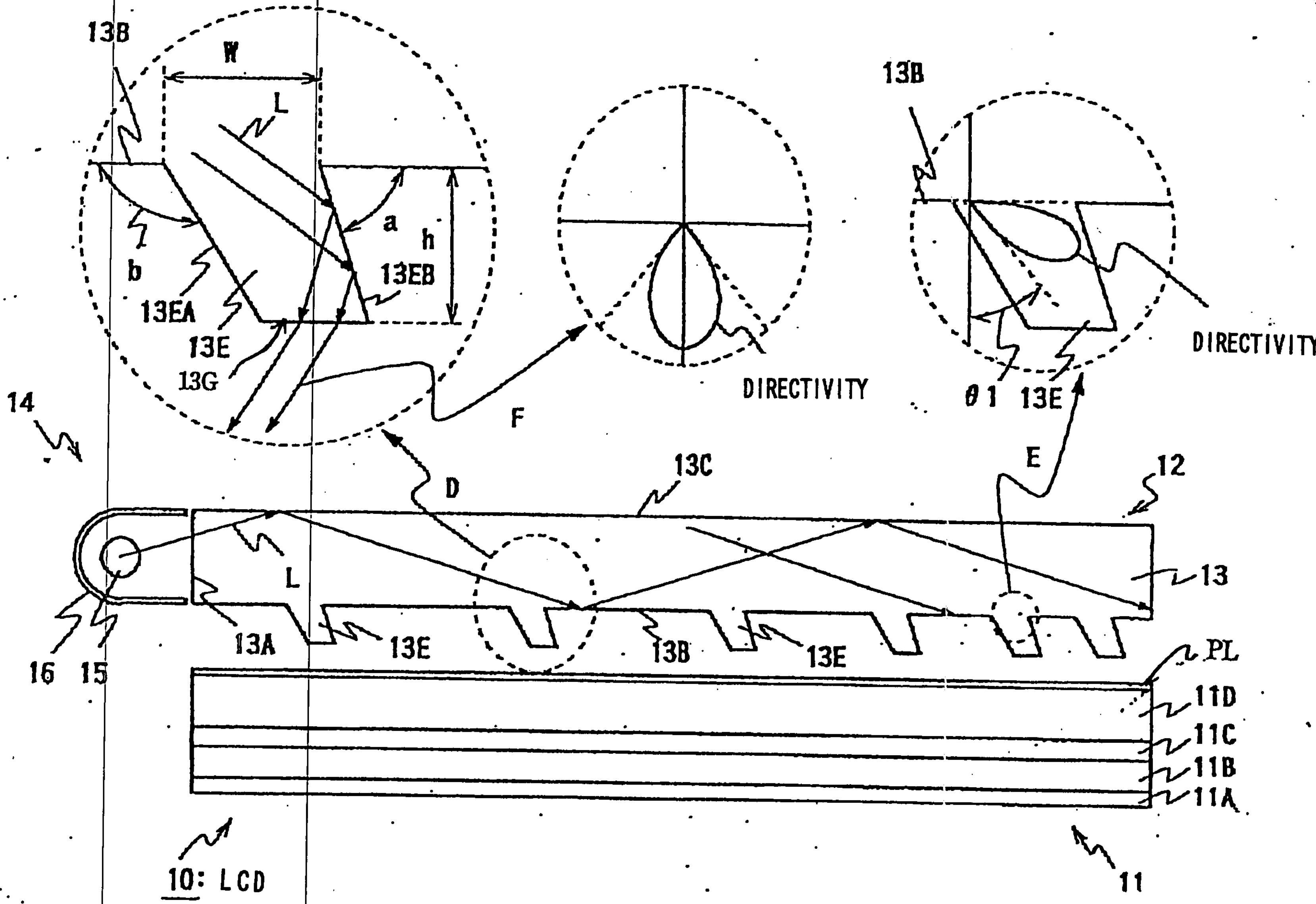
13B
W
L
a
h
b
13EA
13EB
13E
13G
14
DIRECTIVITY
F
13B
DIRECTIVITY
θ1
13E
E
D
13C
12
L
13
16
15
13A
13E
13B
13E
PL
11D
11C
11B
11A
10: LCD
11

Fig.2

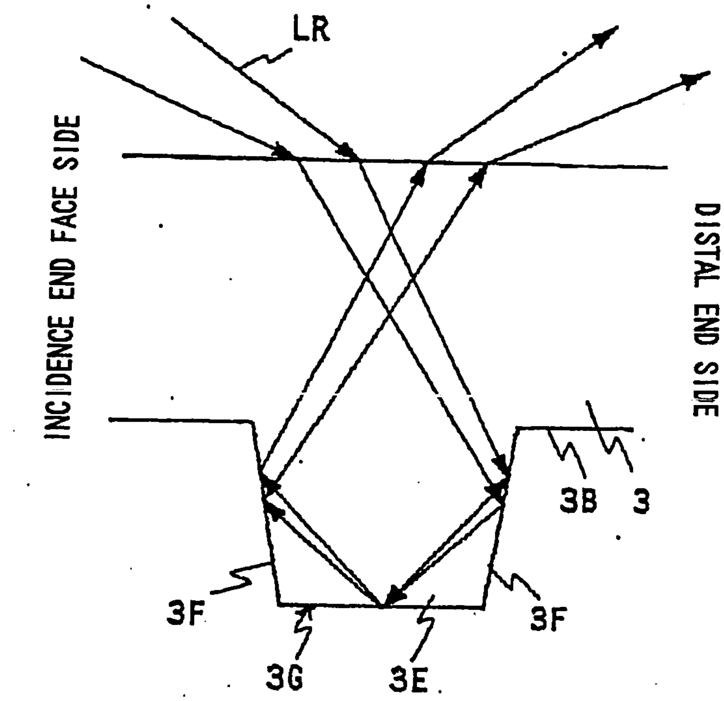
LR
INCIDENCE END FACE SIDE
DISTAL END SIDE
3B
3
3F
3F
3G
3E

Fig.3

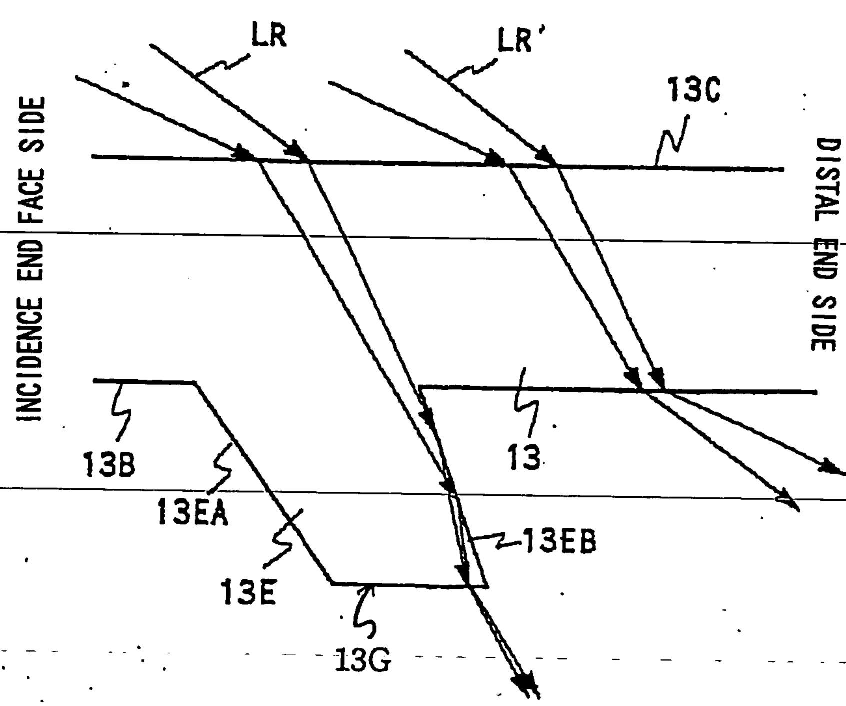
LR
LR'
13C
INCIDENCE END FACE SIDE
DISTAL END SIDE
13B
13
13EA
13EB
13E
13G

Fig.4

(Prior Art)

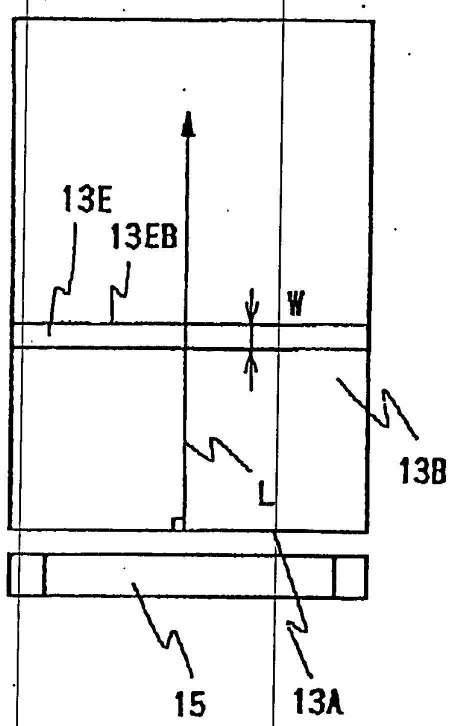

Fig.5a

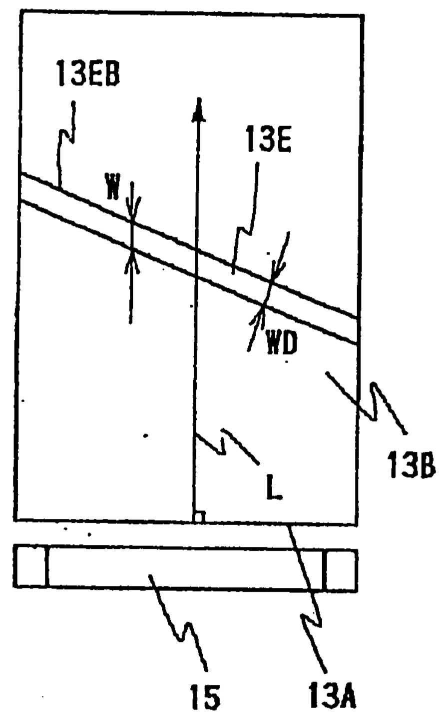

Fig.5b

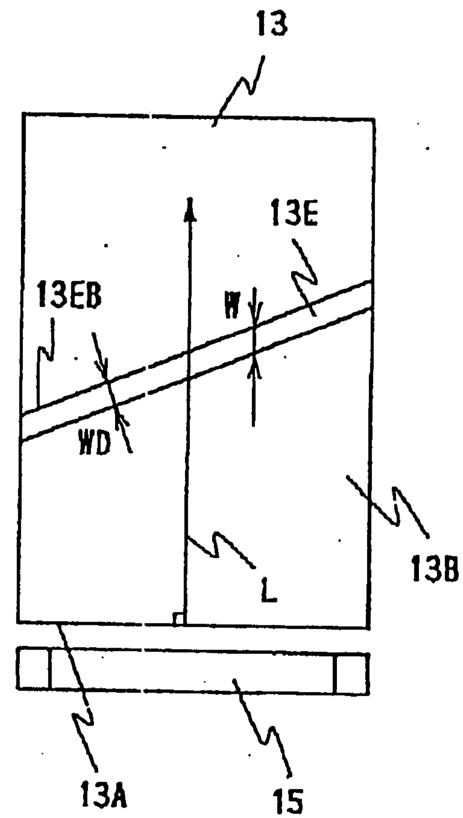

Fig.5c

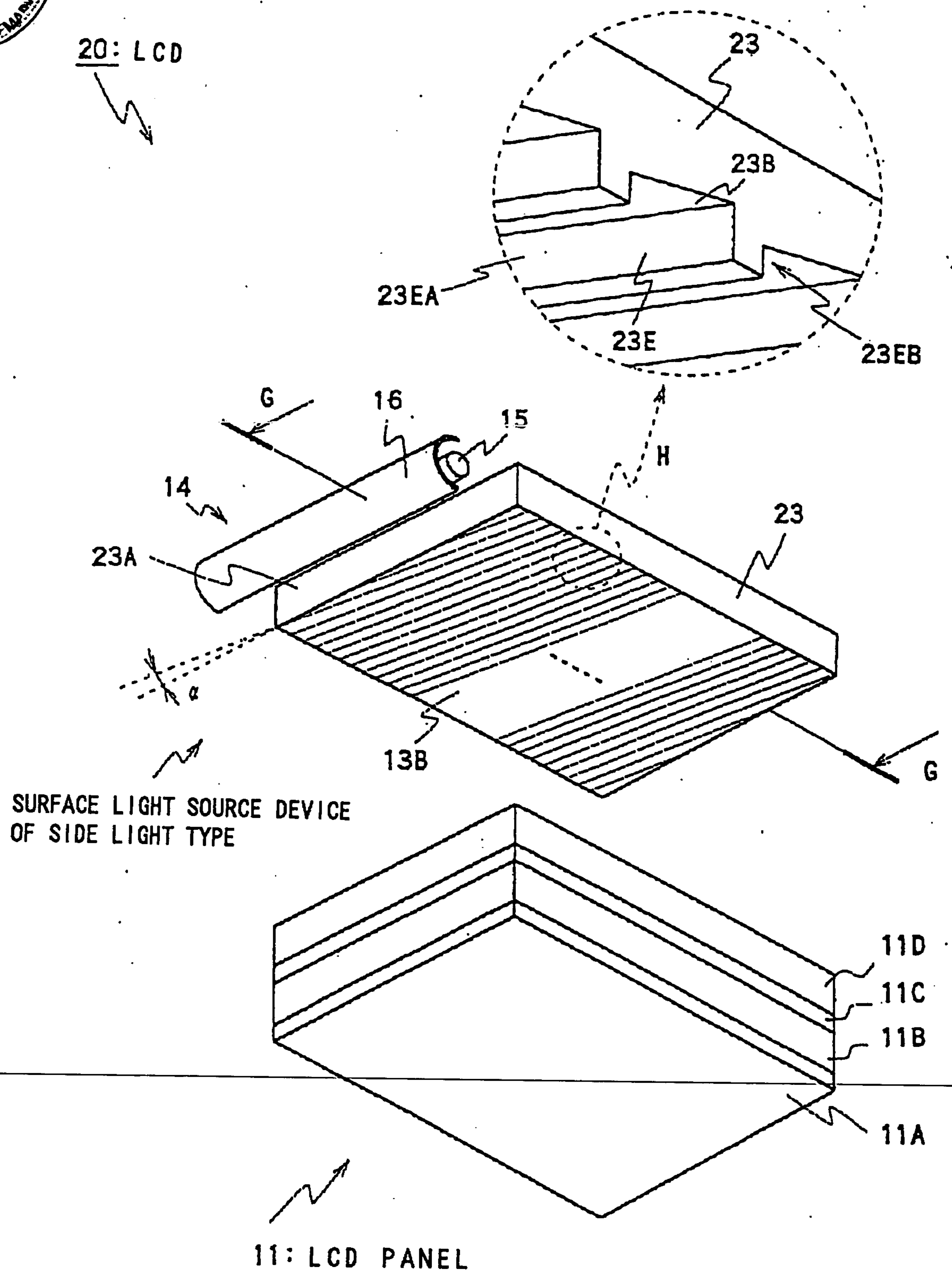
20: LCD
23
23B
23EA
23E
23EB
G
16
15
H
14
23
23A
α
13B
G
SURFACE LIGHT SOURCE DEVICE OF SIDE LIGHT TYPE
11D
11C
11B
11A
11: LCD PANEL

Fig.6

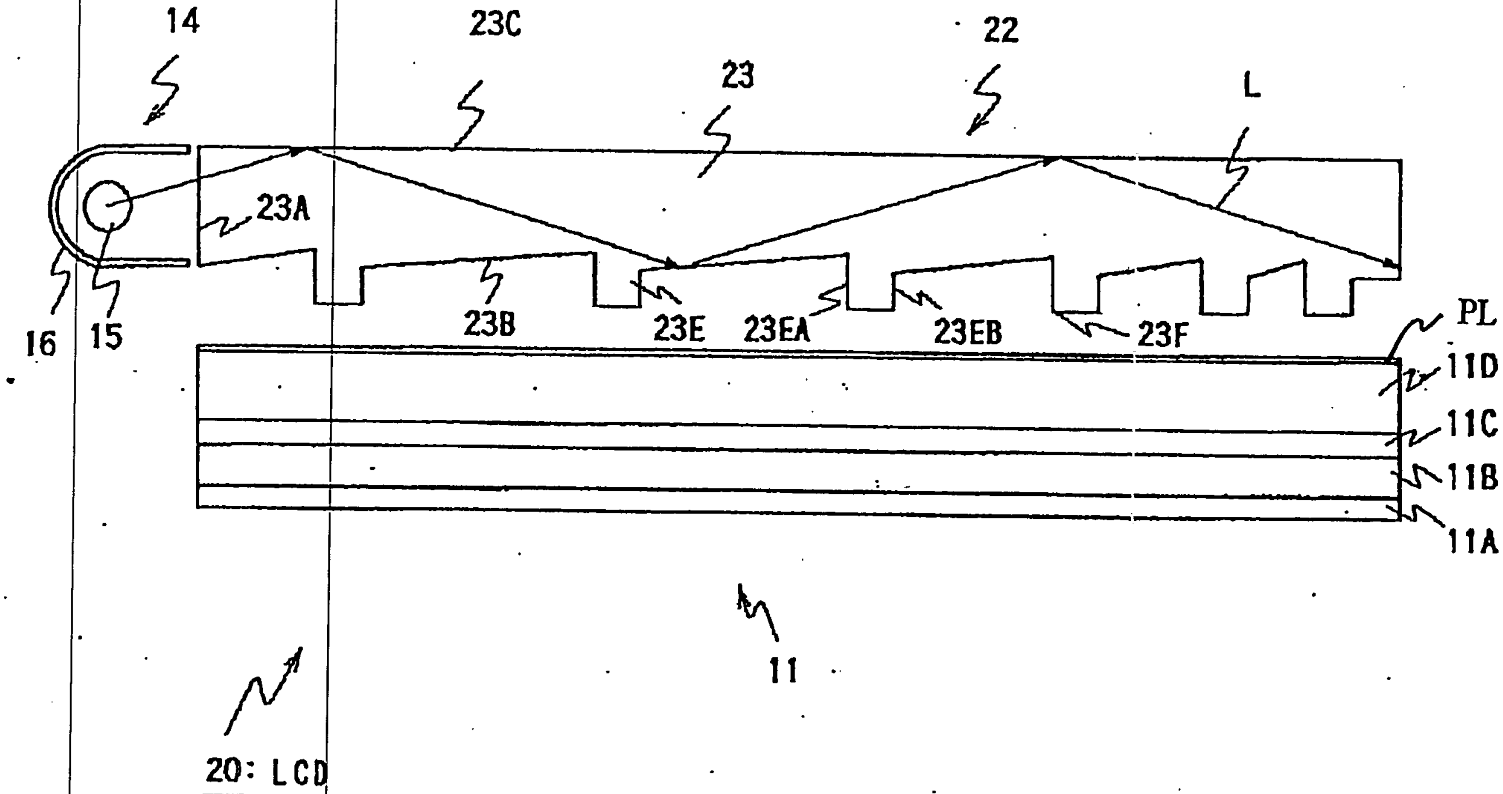
14
23C
23
22
L
23A
16
15
23B
23E
23EA
23EB
23F
PL
11D
11C
11B
11A
11
20: LCD

Fig.7

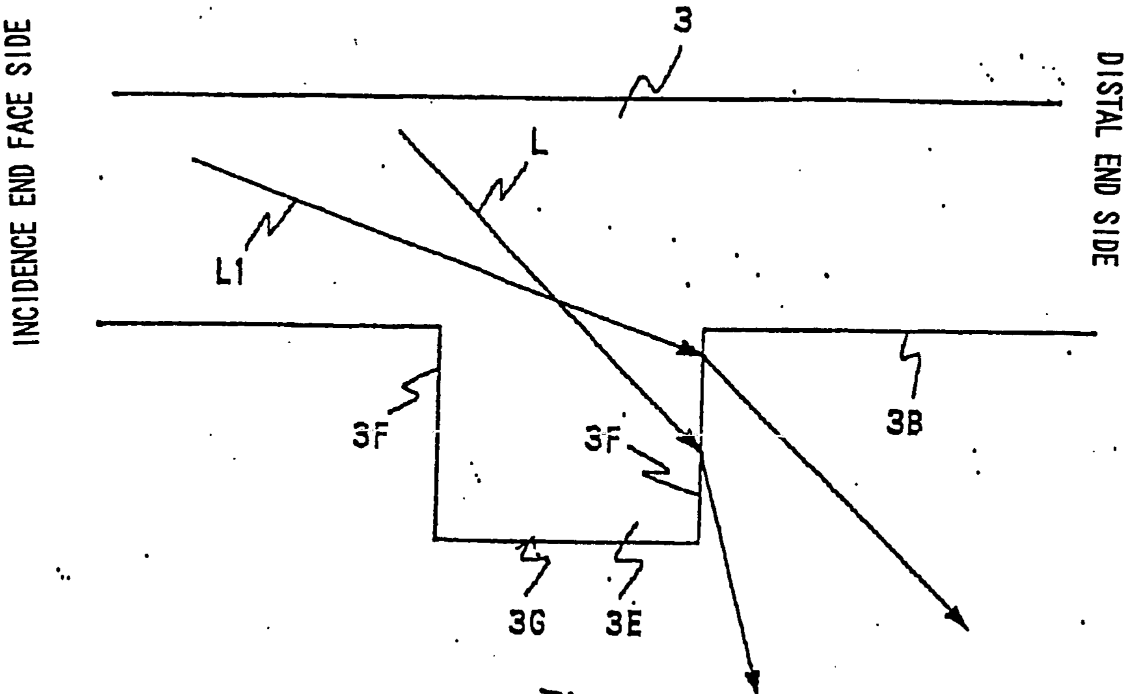
INCIDENCE END FACE SIDE
DISTAL END SIDE
3
L
L1
3F
3F
3B
3G
3E

Fig.8

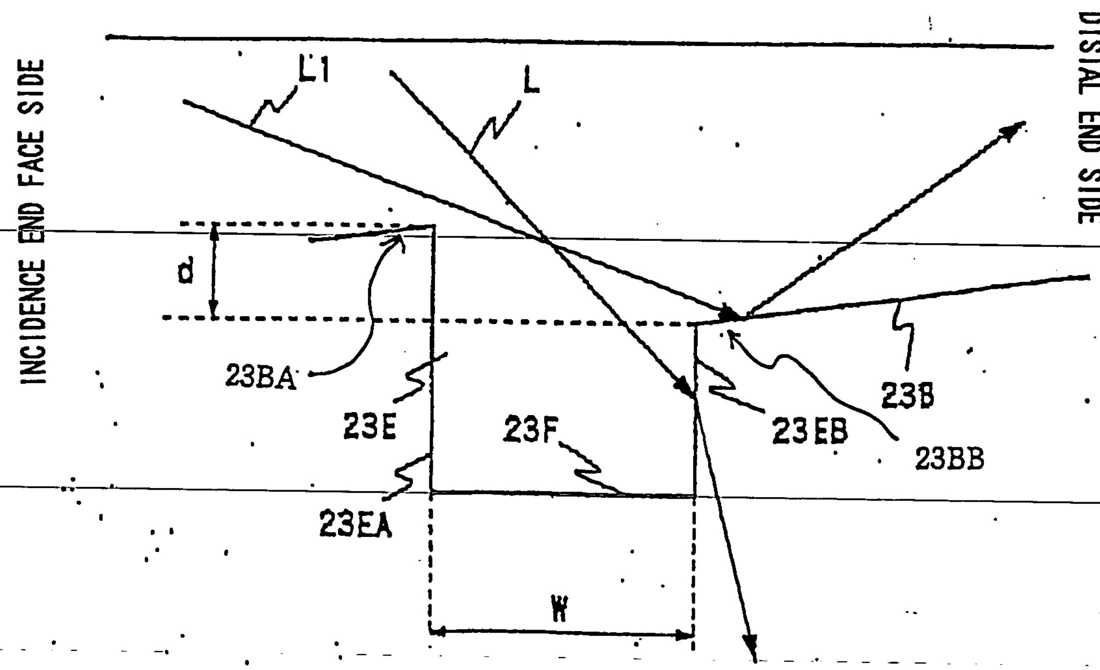
INCIDENCE END FACE SIDE
DISTAL END SIDE
L1
L
d
23BA
23E
23F
23EB
23B
23BB
23EA
W

Fig.9

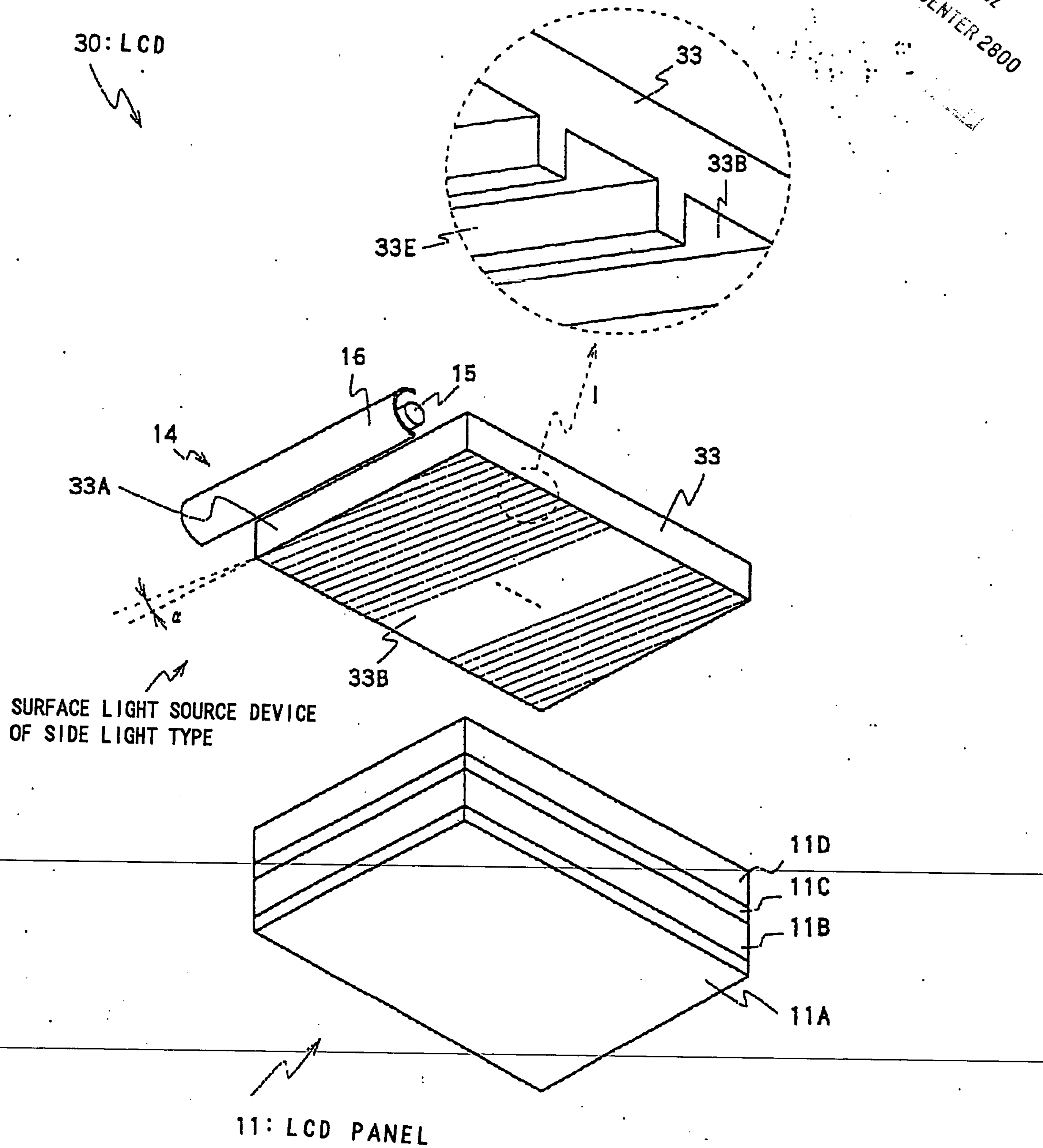
30: LCD
33
33B
33E
16
15
14
33A
I
33
α
33B
SURFACE LIGHT SOURCE DEVICE
OF SIDE LIGHT TYPE
11D
11C
11B
11A
11: LCD PANEL

Fig.10

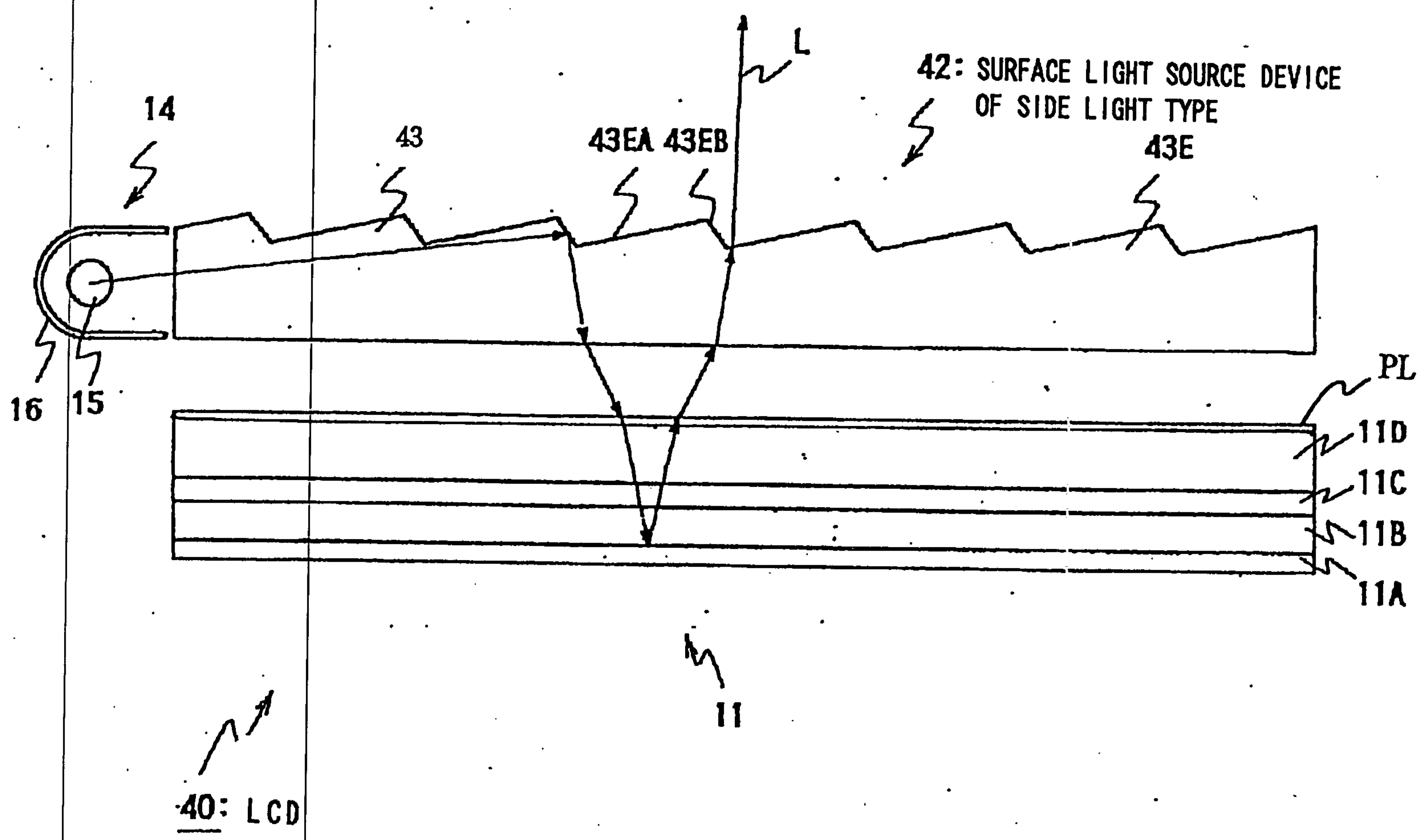
L
42: SURFACE LIGHT SOURCE DEVICE
OF SIDE LIGHT TYPE
14
43
43EA 43EB
43E
16
15
PL
11D
11C
11B
11A
11
40: LCD

Fig.11

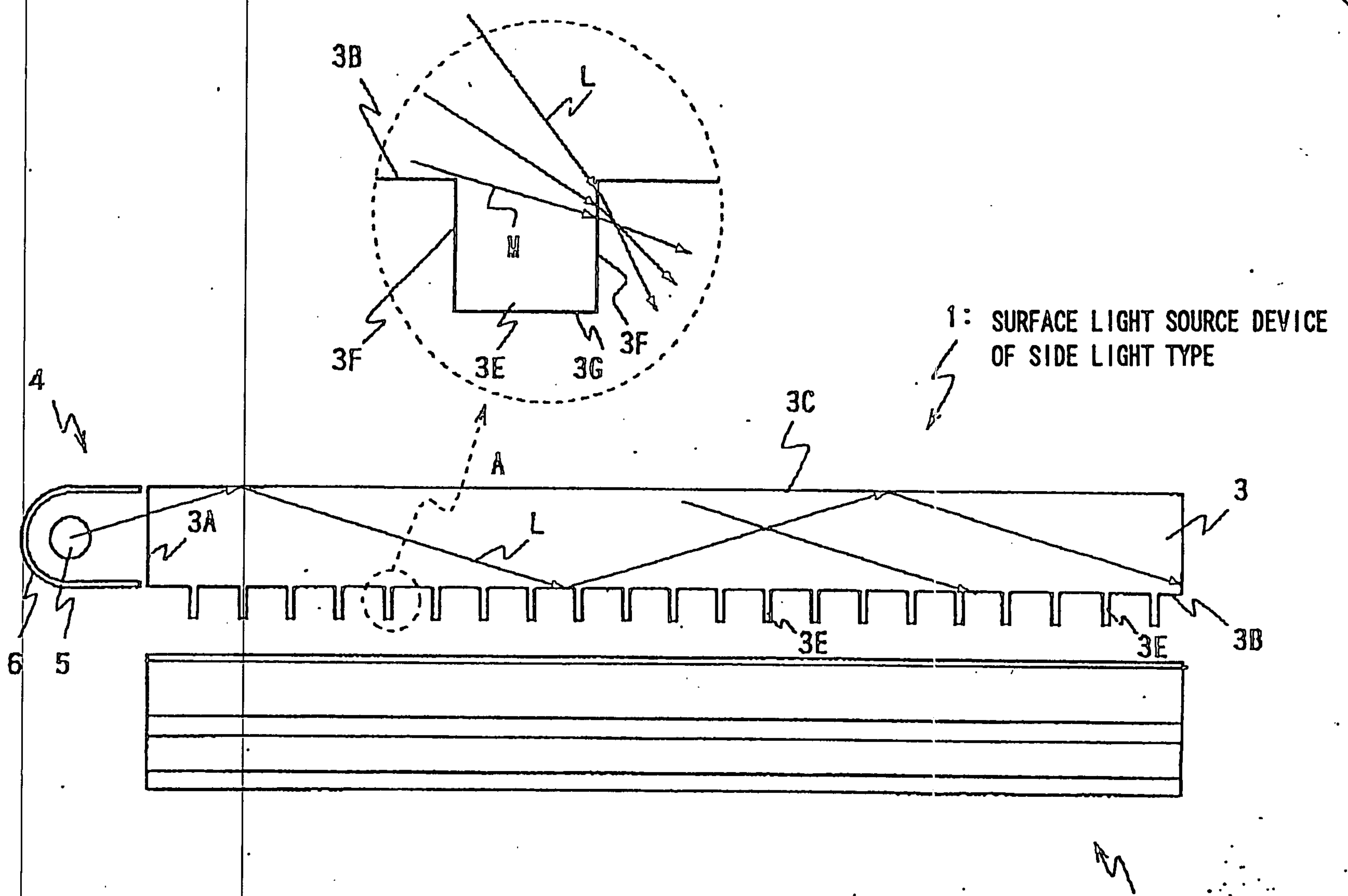
3B
L
M
3F
3E
3G
3F
1: SURFACE LIGHT SOURCE DEVICE
OF SIDE LIGHT TYPE
4
A
A
3C
3
3A
L
6
5
3E
3E
3B
2

Fig.12